IPv4 Mobile Router Testing with the NASA Glenn Aero/Mobile Communications Van

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What was attempted?

- Demonstrate emerging and current communication technologies that distribute IP-based services to a mobile platform (the AC/ATM Aero/Mobile Communications Van).
- Demonstrate the feasibility and utility of using Mobile IPv4 “Networks in Motion” (NEMO) over several diverse communication links to hosts on a mobile platform.
- Select mobile platform communication paths using Mobile IPv4 RFC3344 with NEMO to support a fixed IP subnet with a Cisco 3640 router.

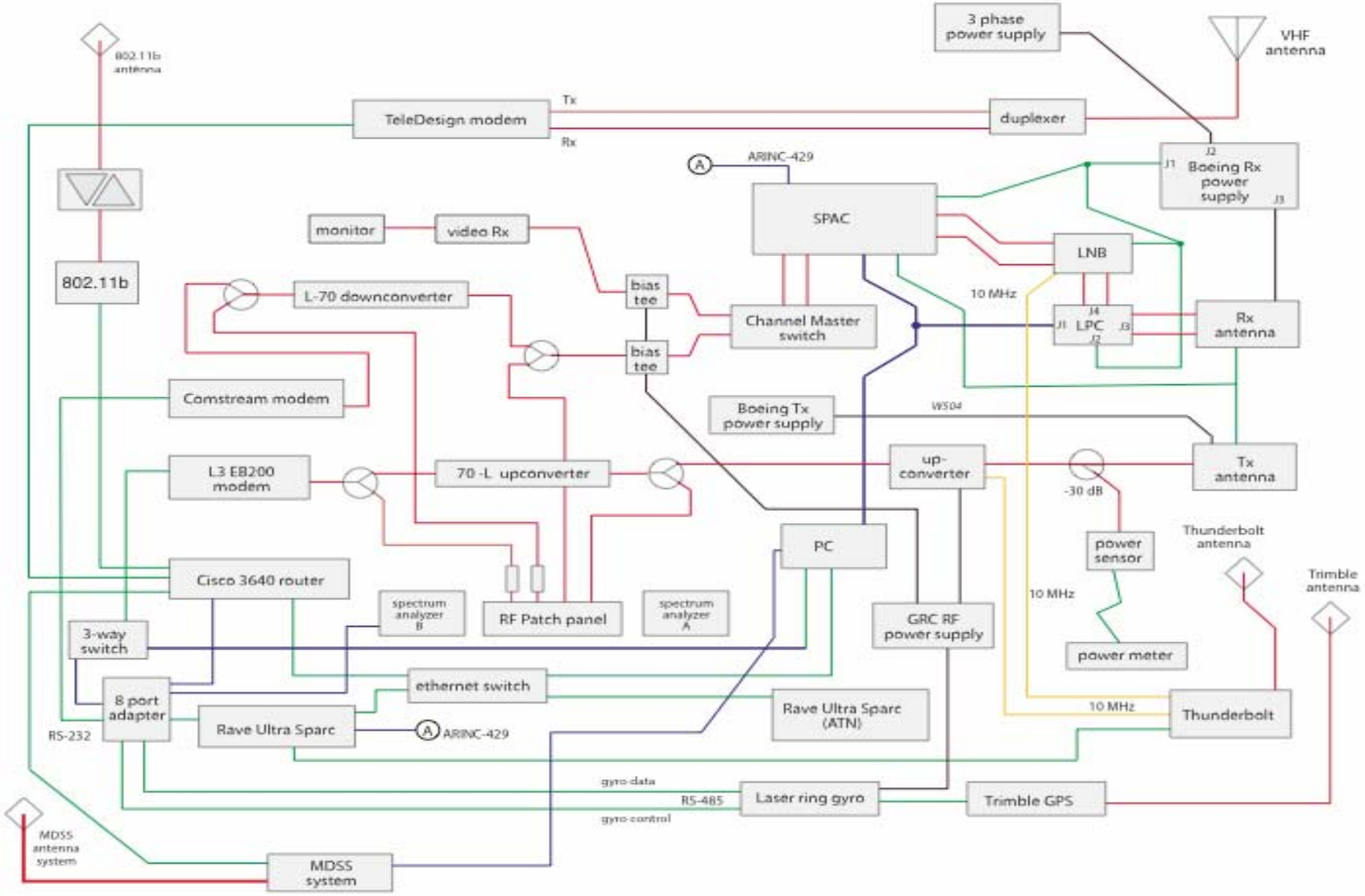
What van capabilities support mobile testing?

- NASA GRC AATT Logging System (NGALS) suite gathers statistics from reachable data sources.
- Any aviation communication system requiring ARINC429 data bus for attitude or position used by antenna systems--created by a ring-laser gyroscope and Global Positioning System(GPS) to generate ARINC429 data.
- Any software that can run under Solaris2.x, Windows2000 and MacOSX on the various computer platforms in the van.
- Flexible system supporting multiple communication links.
- An opportunity to test aeronautical communication systems without the expense or logistical burden of flight testing.

The AC/ATM Aero/Mobile platform

The AC/ATM Aero/Mobile platform (Inside)

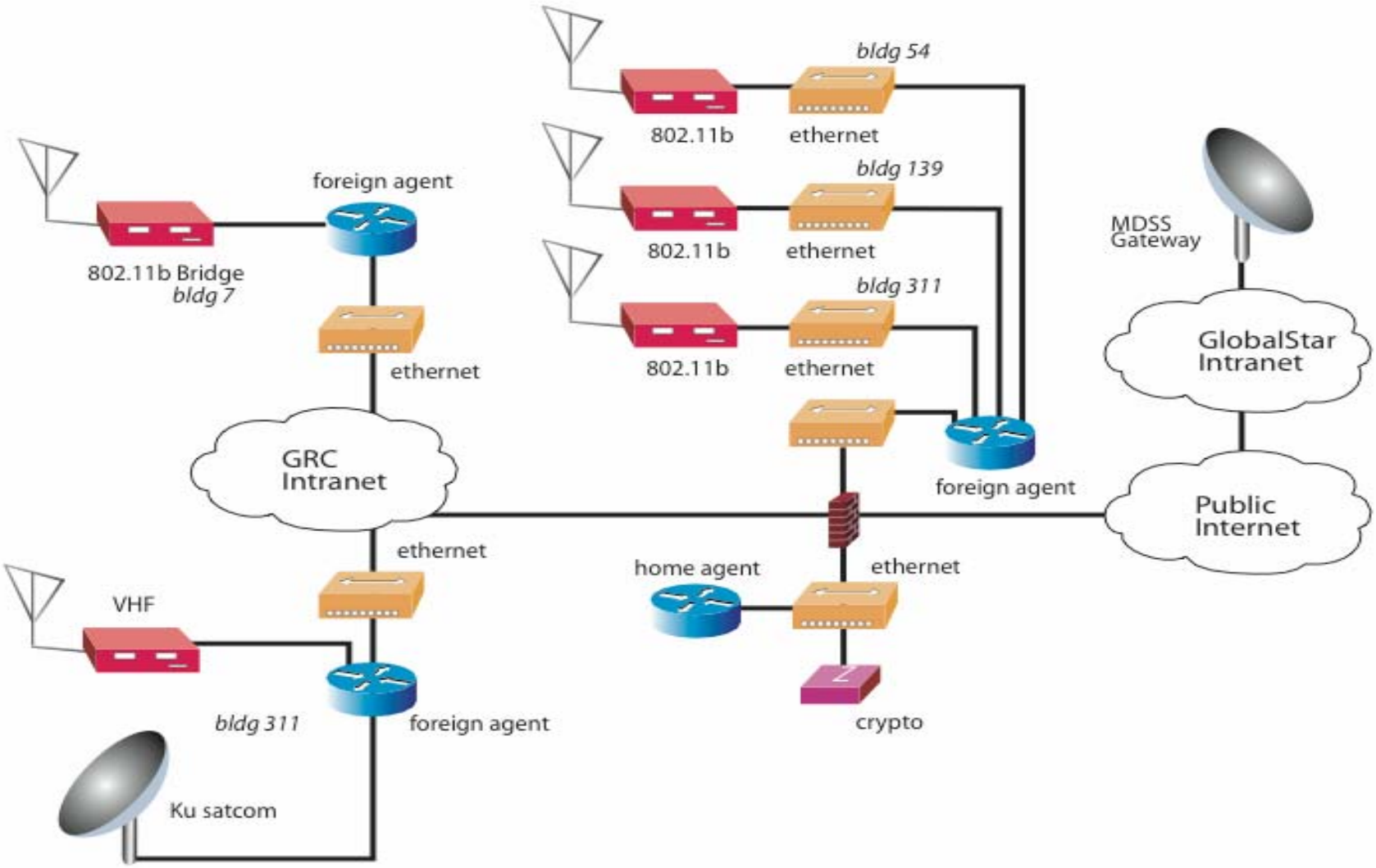
The AC/ATM Aero/Mobile platform (Electronics)



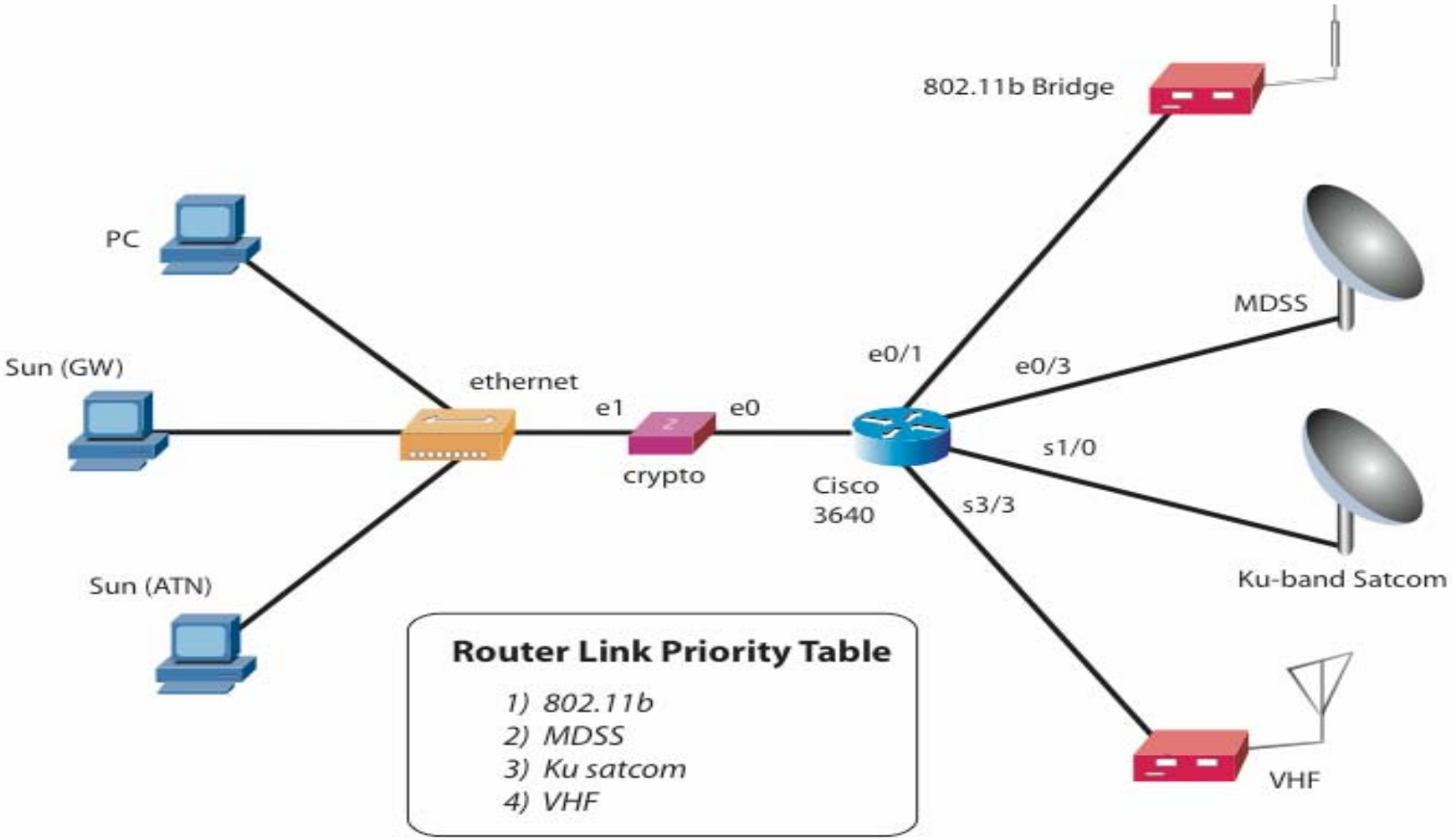
What RF paths were used to the van?

- RF communication paths used for van IPv4 connectivity:
  - Ku-band geosynchronous satellite link with a ~2 Mb/s QPSK downlink and a 256 kb/s Spread Spectrum uplink to GRC's Ku fixed station
  - L-band MDSS satellite link to an offsite fixed link providing IP connectivity back to GRC.
  - VHF 19.2 kb/s link to GRC's fixed station.
  - 802.11B (2 -11 Mb/s) connectivity up to 4 bridge points around the GRC campus.

What does the ground (fixed) network look like?



What does the mobile network look like?



Test Descriptions

- The tests were designed to demonstrate Internet services between mobile hosts on the Aero/Mobile Communications Van and hosts located on the NASA Glenn network and other outside internet hosts.
- While moving between different attachment points, the mobile IPv4 network provides a fixed IPv4 address to non-mobile hosts trying to reach the mobile network using various “foreign” networks as “tunnels” to the home network.
- For each test, several physical links were set up and then the van was driven around to use different Foreign Agents to connect back to its home network.
- The on-board router selects the physical communication paths based on prioritization scheme and the currently available paths:
  - 802.11b (highest priority)
  - MDSS,
  - Ku-band satcom
  - VHF (lowest priority)

What were the test goals?

- Examine the behavior of the aero/mobile van's Mobile Router while driving around the NASA Glenn campus using the 802.11b (using two different access points) and VHF links. Record Mobile Router, UDP and TCP statistics as necessary.
- Can the aero/mobile van's Ku-band system support a full duplex link between the mobile and fixed stations using a commercial Ku satellite?
- Confirm a stationary aero/mobile van can switch between VHF, MDSS, Ku-band and 802.11b while links are powered off and on. The fixed van tests are for initial testing before driving the van around.
- Confirm the moving aero/mobile van can switch between VHF, MDSS, Ku-band and 802.11b while links become available and unavailable due to the location of the van.
- Confirm Internet services (ftp and http) between the mobile hosts and non-mobile hosts while in motion.

Select Test Results and Comments

- The Mobile Router maintained a 128 kb/s UDP stream between a fixed and mobile host while under motion using the 802.11b link and VHF link.
- A full duplex Ku satellite link was established between the fixed and mobile hosts:
  - fixed-to-mobile link: 2 Mb/s, E_b/N_o = 10.3 dB, channel BER ≈ 0
  - mobile-to-fixed link: 256 kb/s, E_b/N_o = 9.0 dB, channel BER ≈ 0
- Confirmed a stationary aero/mobile van can switch between VHF, MDSS, Ku-band and 802.11b while links are powered off in various combinations.
- All four links (802.11b using two different access points, VHF, MDSS and Ku satcom) were powered off and on and the Mobile Router switched based on priority.
- Confirmed the aero/mobile van Mobile Router switches between VHF, MDSS, Ku-band and 802.11b link while under motion based on link priority and availability.
- TCP/UDP applications successfully transferred data between mobile and fixed computers as the router switched between available communication links while under motion:
  - two different 802.11b access points, MDSS, VHF and Ku satcom.
- Successfully transmitted web cam images using ftp to a fixed host at Glenn.

Select Data Sets

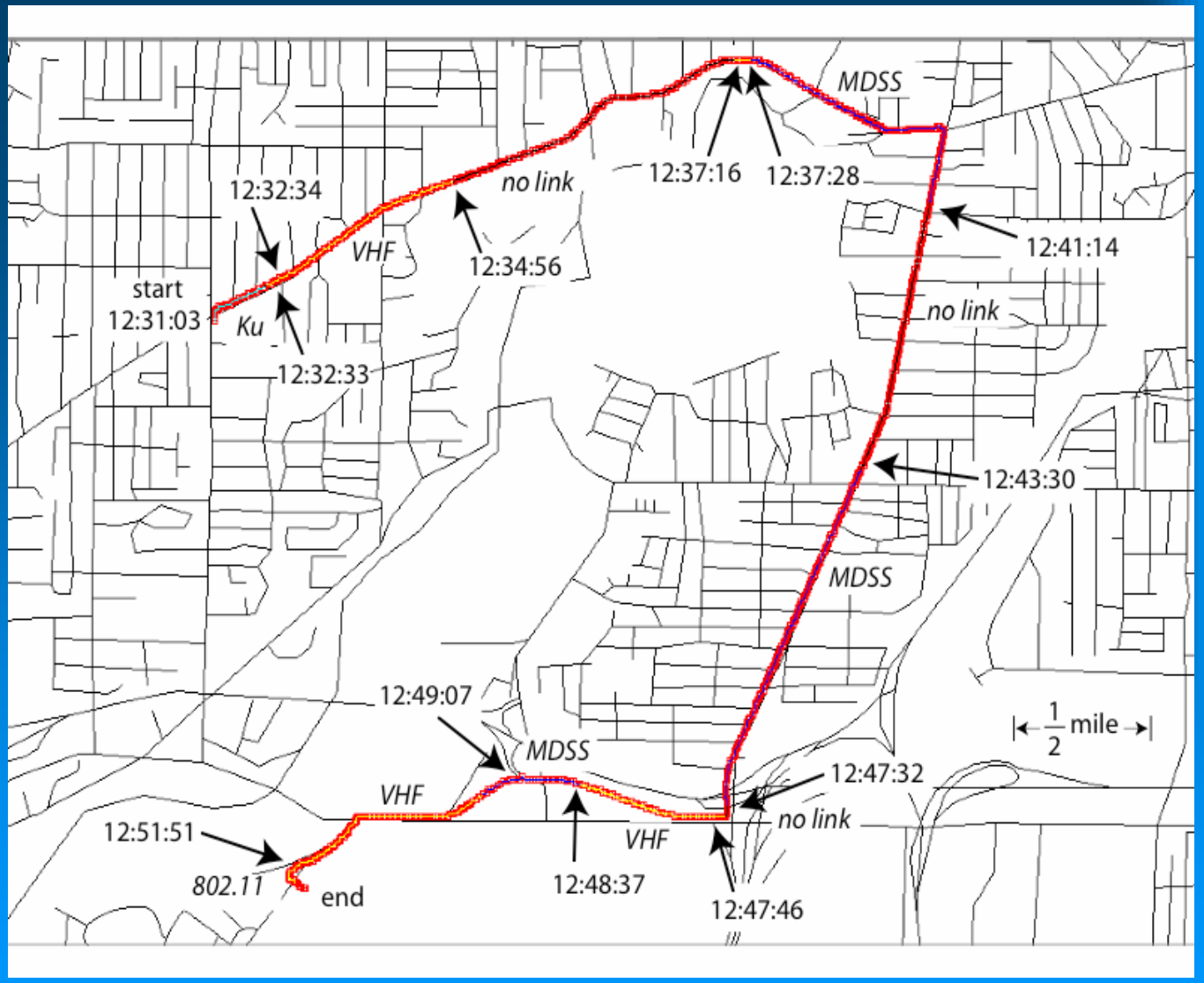
- The graphical output is from several test runs while in motion.
- The van's latitude/longitude position (updated every 1/10 second) is combined with the router's currently associated link (updated approximately every 2 seconds) into a map.
- The graphs display the number of received bytes of TCP segments and UDP messages at a computer's ethernet interface over time.
- The maps and graphs were created from several programs:
  - Miploggerd, insd, logger, parse and mipdebug2csv
    - NASA Glenn Research Center locally developed analysis tools
  - Openmap
    - BBN Technologies, Inc: Openmap Version 4.6 - *http://www.openmap.org*
  - Tcpdump
    - Lawrence Berkeley National Laboratory (LBNL): Tcpdump 3.8.1 - *http://www.tcpdump.org*
  - Iperf
    - National Laboratory for Applied Network Research at University of Illinois at Urbana Champaign: Iperf Version 1.7.0 -*http://dast.nlanr.net/Projects/Iperf/*

Test run descriptions

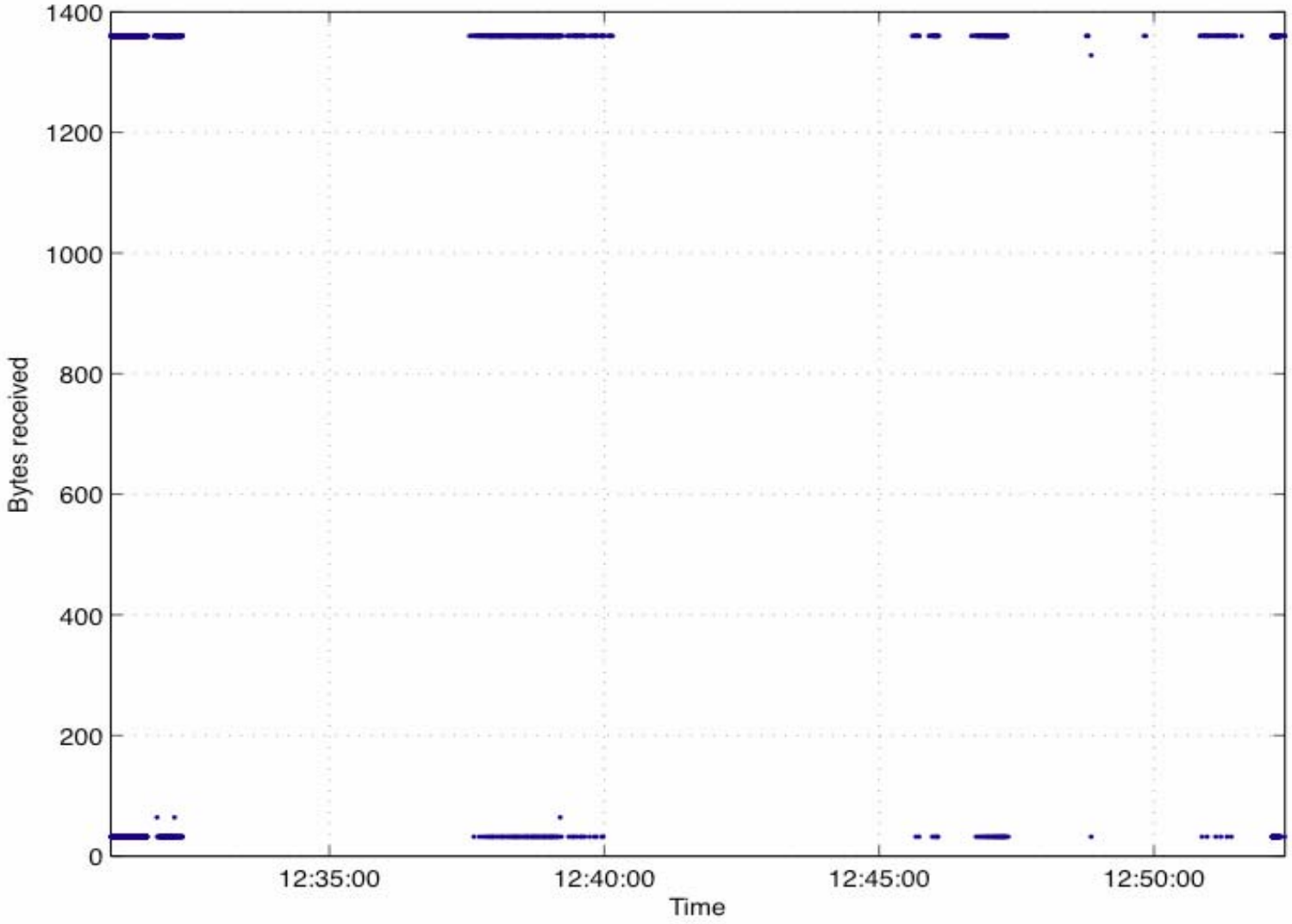
- Iperf generated two TCP streams to simulate 8192 byte network writes between a fixed workstation and a mobile workstation.
- Iperf used 18 kB TCP buffers on the mobile-to-fixed direction and 150 kB TCP buffers on the fixed-to-mobile direction.
- The van's web camera transferred 16 kB pictures to a ground webserver directory every minute using the ftp protocol.

Mobile Platform Multi Link Switchover

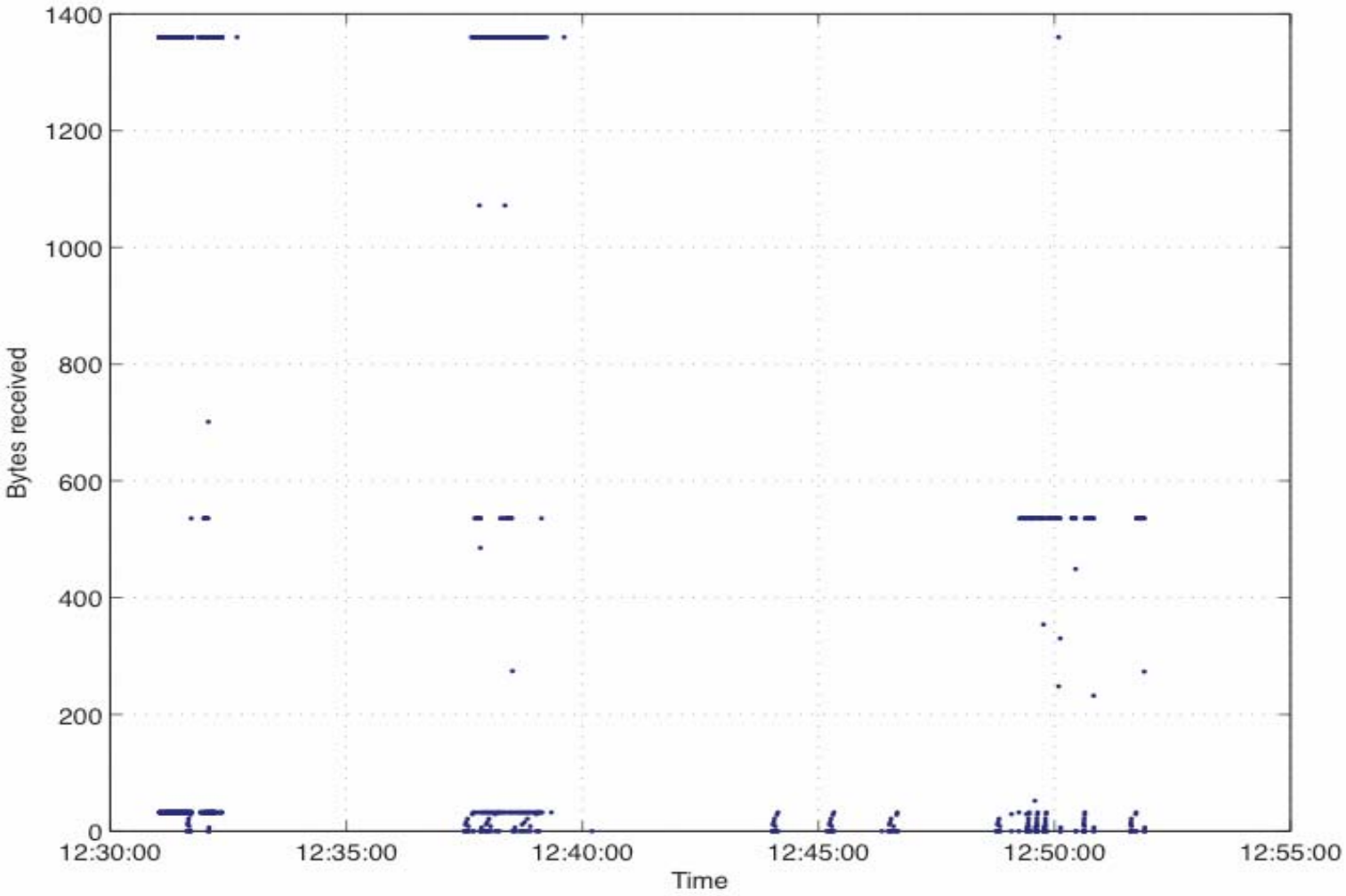
- Map of link switchovers while driving north of the GRC campus on March 2nd, 2004.
- The map is a 20 minute subset of a 70 minute test.
- Link priority:
  - 802.11B(High)
  - MDSS
  - Ku-band
  - VHF(Low)



Received Protocol data on mobile host's interface 03/02/04

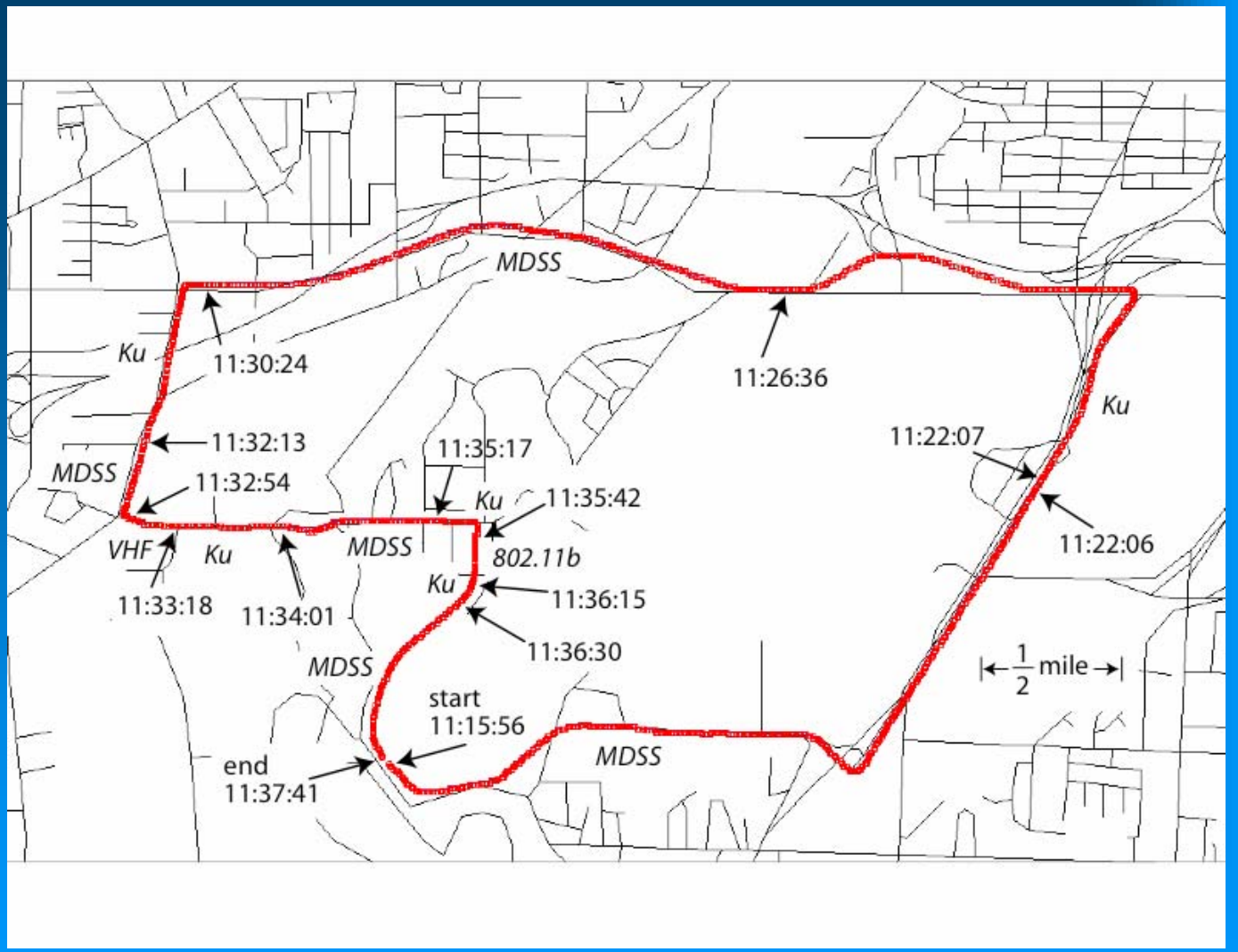


Received Protocol data on fixed host's interface 03/02/04

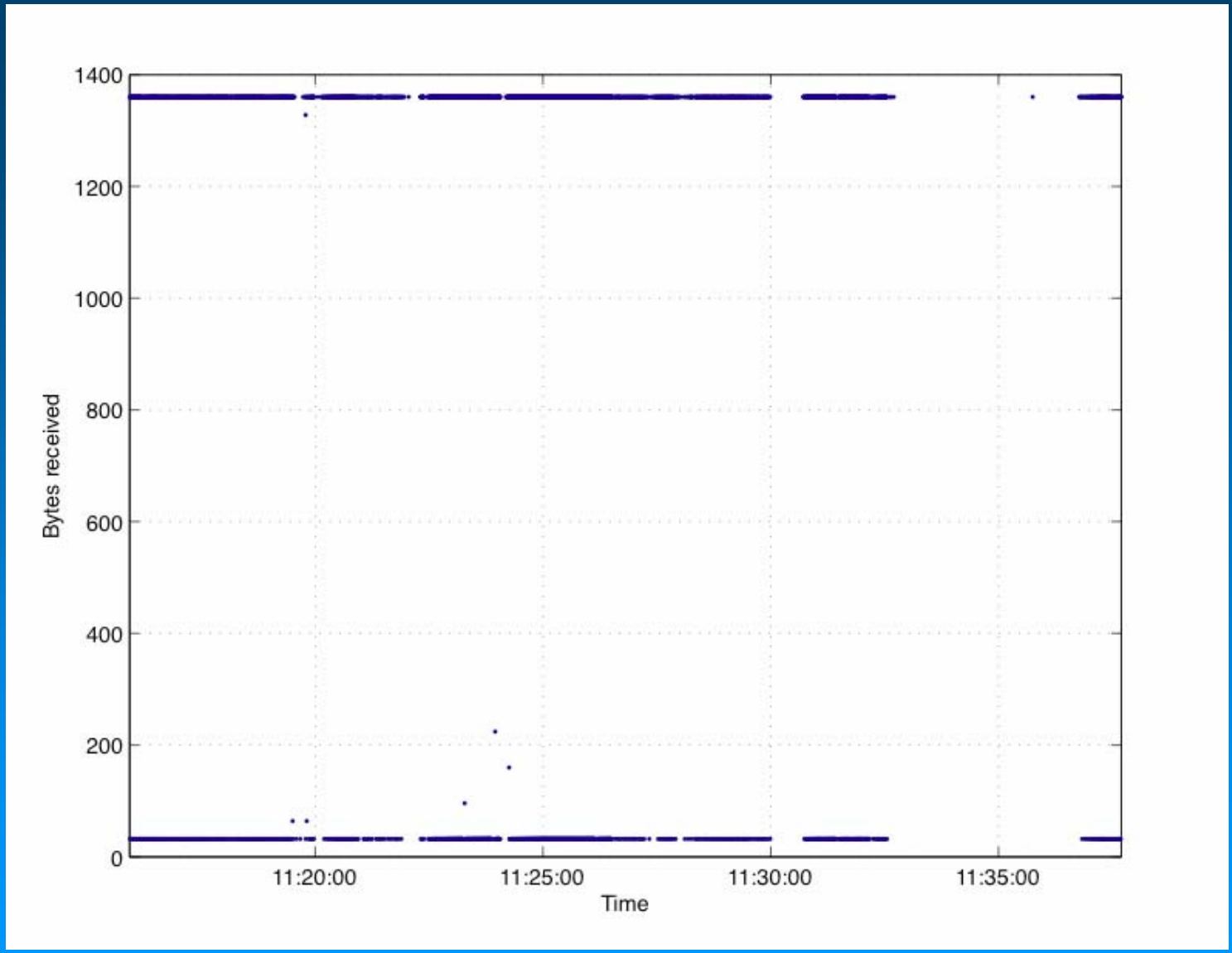


Mobile Platform Multi Link Switchover

- Map of link switchovers while driving outside the GRC campus on March 2nd, 2004.
- The map is a complete run.
- Link priority:
  - 802.11B (High)
  - MDSS
  - Ku-band
  - VHF (Low)



Received Protocol data on mobile host's interface 03/02/04



Mobile Platform Uplink during test runs

- AXIS2100 web camera uploads a low resolution jpeg picture to a ground ftp server every minute.
- This demonstrates IP-based telemetry from the mobile platform to a fixed server.

Conclusions

We were successful in demonstrating:

- AC/ATM Aero/Mobile Communications Van as a communications simulation testbed for an aircraft in motion
- performance monitoring and data logging of all the communications equipment on the mobile platform
- TCP and UDP transport to a mobile network in motion
- integrating multiple communications systems into a testbed with a mobile network with fixed IP addresses using Mobile Router.